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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/663,304	09/16/2003	Kallol Bera	8477/ETCH/DRIE	1356

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EXAMINER

PHAM, THANH V

ART UNIT

PAPER NUMBER

2823

DATE MAILED: 12/15/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/663,304	BERA ET AL.	
	Examiner	Art Unit	
	Thanh V Pham	2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 14 October 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-39 is/are pending in the application.
- 4a) Of the above claim(s) 18-39 is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-17 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|---|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date <u>09/16/03</u> | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Election/Restrictions

1. Applicant's election without traverse of Group I, claims 1-17, in the reply filed on 10/14/04 is acknowledged.

Specification

2. The disclosure is objected to because of the following informalities: page 7, paragraph 29, "FIG. 2L" should be -- Fig. 2I--. Appropriate correction is required.
3. Claim 4 is objected to because of the following informality: "comprises" in line 2 should be --comprise--. Appropriate correction is required.
4. Claim 17 is objected to because of the following informalities: "CF₄ and CF₄" and "CF₄:CF₄" in line 3 should be --CF₄ and N₂-- and --CF₄:N₂-- respectively. Appropriate correction is required.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

6. Claims 1-6, 8-10 are rejected under 35 U.S.C. 102(a) as being anticipated by Jiang et al. US 6,797,633 B2.

Re claim 1, the Jiang et al. reference discloses a method of fabricating an interconnect structure, which “may be the first or any subsequent metal interconnect level of the semiconductor device 120” (col. 3, lines 24-26), comprising:

(a) providing (first metal interconnect level of the semiconductor device 120 being formed) a substrate 100 having a film stack comprising sequentially formed on the substrate a first barrier layer 101, a conductive layer 124 embedded in a first dielectric layer 102/104 (fig. 1F), (subsequent metal interconnect level of the semiconductor device 120 being formed) a second barrier layer 101, a second dielectric layer 102/104, and a cap layer 105 (fig. 1A);

(b) etching a via hole 106 in the cap layer and the second dielectric layer 102/104 (fig. 1C);

(c) filling a portion of a depth of the via hole with a masking material 107 (fig 1D);

(d) etching in-situ the cap layer 105, a trench 108 in the second dielectric layer 102/104, the masking material 107, and the second barrier layer 101 (figs. 1E and 1F);
and

(e) metallizing the via hole and the trench (fig. 1F).

Re claim 2, wherein the cap layer comprises SiO_xN_y , where x and y are integers (col. 3, line 40).

Re claim 3, wherein the first dielectric layer and the second dielectric layer comprise at least one of carbon doped silicon oxide, organic doped silicon glass, and fluorine doped silicon glass (col. 3, lines 28-36).

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Re claim 4, wherein the first barrier layer and the second barrier layer comprise at least one of SiO₂, SiC and Si₃N₄ (col. 1, line 52).

Re claim 5, wherein the conductive layer comprises at least one of Cu, Al, Ta, W, Ti, TaN and TiN (col. 2, line 41).

Re claim 6, wherein the masking material is selected from a group consisting of an organic material and photoresist (col. 4, lines 9-14).

Re claim 8, wherein the step (c) further comprises: applying the masking material 107 to the substrate to fill the via hole 106; and etching back the masking material 107 until the masking material is removed from the via hole to a pre-determined depth that is smaller than a depth of the trench (col. 4, lines 9-15).

Re claim 9, wherein the etching step further comprises: providing O₂ at a flow rate from about 100 to 1000 sccm; maintaining a chamber pressure at about 5 to 200 mT; and applying a cathode bias power between 100 and 400 W (col. 3, lines 1-4).

Re claim 10, wherein the step (d) further comprises: forming on the cap layer a second patterned etch mask 132 to define the trench 108; and stripping the second patterned etch mask 132 contemporaneously with etching the masking material (col. 4, lines 27-30).

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

8. Claims 7 and 11-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jiang et al. as applied to claims 1-6, 8 and 10 above, and further in view of Chun et al. TW 544815 A, Ma et al. US 2004/0161930 A1 and Samukawa et al. US 6,177,146 B1.

The Jiang et al. reference discloses substantially all of the steps of the instant invention, teaches the use of O₂ plasma and other chemistries with or without inert gases to treat low-k films without damage to the OSG film but remove the resist (col. 3, lines 45-67) "[t]he exposure energy required to clear resist inside a via is the lowest for the wafer with in-situ O₂ plasma ash, indicating the most robustness for fighting poisoning" (col. 4, lines 15-26).

The Jiang et al. reference lacks:

the ratio of CF₄:N₂ in a range from 1:1 to 1:5 in forming the via hole, *re claim 7*.

The four sub-steps in step (d) of Jiang et al. are summarized as "[t]rench pattern 132 and BARC 107 are then removed. The capping layer 105 and etch stop layer 101 are removed next during and etch stop etch" (col. 4, lines 28-30) without details of VHF frequency, bias power at a frequency, or source power and the ratio of CF₄:N₂ in each sub-step, *re claims 11-17*.

Re claim 7, the Jiang et al. reference discloses in the step (b): forming a first patterned etch mask 130 on the cap layer 105 to defined the via hole 106; etching the via hole; and stripping the first patterned etch mask (figs. 1C and 1D).

The Jiang et al. reference does not disclose providing CF_4 and N_2 at a flow ratio $\text{CF}_4:\text{N}_2$ in a range from 1:1 to 1:5.

The Chun et al. reference teaches etching through a cap layer on the dielectric layer using N_2 and CF_4 in the ratio of 0-10:1.

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the via hole etching of Jiang et al. with the ratio of $\text{CF}_4:\text{N}_2$ as taught by Chun et al. because that ratio of Chun et al. would improve the etching of nitride to oxide layer as taught by Jiang et al.

Re claims 11-17, the four sub-steps in step (d) of Jiang et al. are summarized without details of VHF frequency, bias power at a frequency, or source power and the ratio of $\text{CF}_4:\text{N}_2$ in each sub-step.

The Ma et al. reference discloses in-situ discharge to avoid arcing during plasma etch method wherein an inert gas and an etching gas are flowed into the chamber during the etching sequence (figs. 2-5) wherein the power is between 100 and 1000 Watts while chamber pressure is held between 20 and 150 mTorr [0028], a fluorocarbon gas $\text{C}_x\text{F}_y\text{H}_z$ where x and y are integers equal or greater than 1 and z is either 0 or an integer equal or greater than 1; the flow rate of fluorocarbon gas is between 0 and 50 sccm may be combined with N_2 and other fluorocarbon gas, the flow rate of the additional gas is also from 0 to 50 sccm, the same RF power, chamber pressure and time period apply in one step as in the other previous step [0029], the choice of gas from the discharge may be a matter of convenience [0033].

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the sub-steps of Jiang et al. with the power, pressure and flow rates as taught by Ma et al. because the power, pressure and flow rates of Ma et al. would provide the sub-steps of Jiang et al. with in-situ discharge to avoid arcing during plasma etch processes.

The combination lacks an indication of the frequency of the VHF; however, Samukawa et al. teaches that the etching by exposing to plasma has been widely applied since it is highly practicable. High-density plasma etching generated in the course of electric discharge caused by applying an electric field of high frequency ranging in VHF to UHF bands, nearly from 100 to 1,000 MHz (col. 1, lines 20-47).

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the process of the combination with an appropriate VHF frequency as taught by Samukawa et al. The use of frequency ranging in VHF to UHF bands in plasma etching is well known to those skill in the art as taught by Samukawa et al.

Conclusion

9. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thanh V. Pham whose telephone number is 571-272-1866. The examiner can normally be reached on M-Th (6:30-5:00).

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 571-272-1855. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

TvP

TvP
12/07/2004


George Fourson
Primary Examiner